Johnson (F. P.) al

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BASIN AND WELL COVERING

—OF THE—

WALTHAM WATER WORKS.

—BY—

F. P. JOHNSON,
City Engineer.

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Presented by the author

BASIN AND WELL COVERING OF THE WALTHAM WATER WORKS,

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(Read December 13, 1893.)

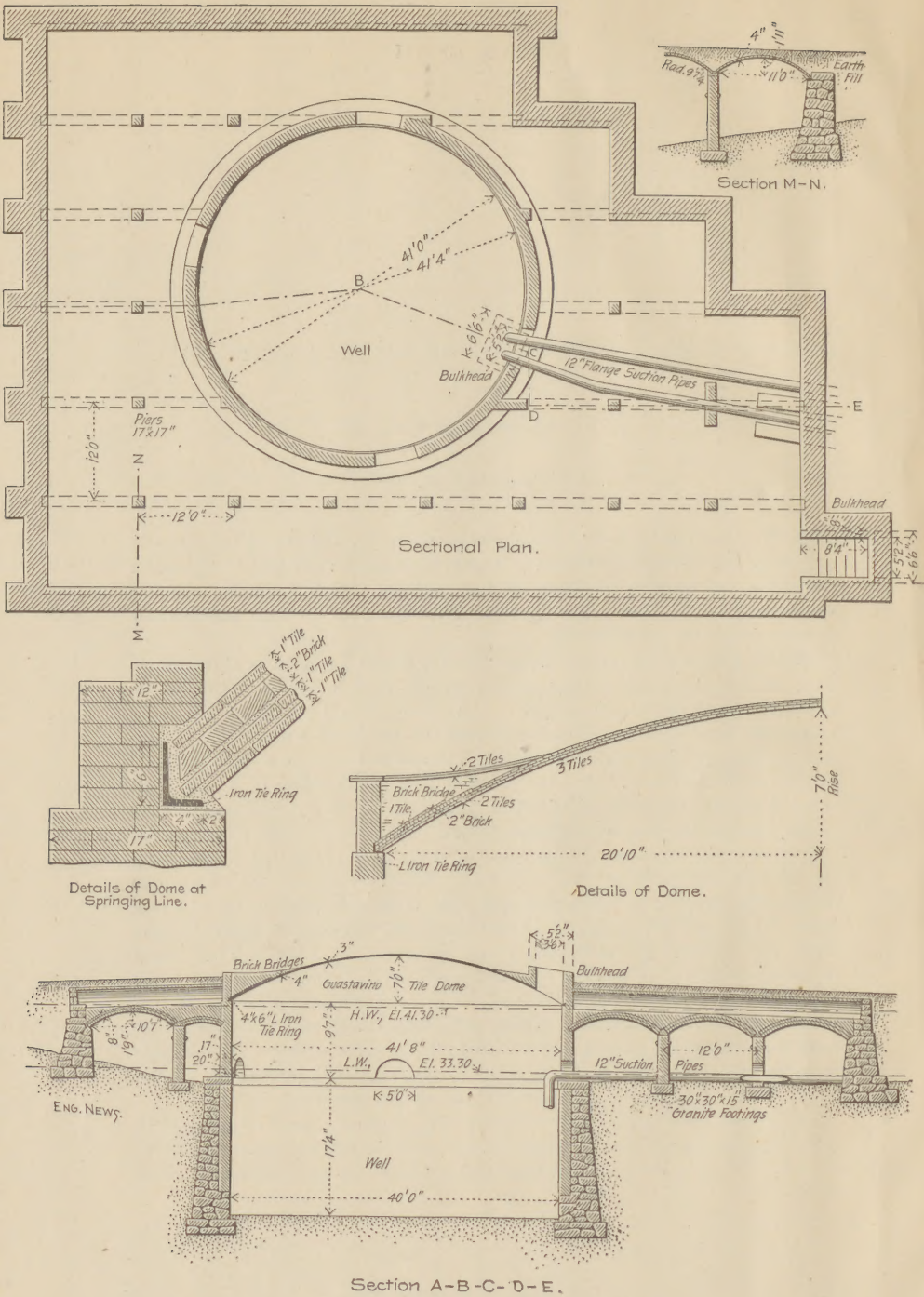
Mr. Winslow has spoken of the character of the ground at and immediately adjoining our pumping station. It may, perhaps, be in order to add just a word as to the peculiar situation of the well, by which its water shed is virtually enlarged, and which has perhaps much to do with the notable copiousness of its water supply.

What is known to geologists as the "Boston Basin," a gigantic sink hole or depression of the earth has its circumscribing fault (or seam in the rocks) passing just about under our well. The well being sunk in exceptionally loose drift material at the edge, so to speak, of the basin with ledge an unknown distance down while the ground changes in character a short distance to the north and west, ledge there being near the surface of a farm and wooded country of glacial drift not so much acted upon by moving waters.

Our conditions are somewhat exceptional.

Scarcely had I taken charge, last March, of the work of the City Engineering Department of Waltham when the Water Board requested me to prepare designs for covering the basin and well so as to exclude light, or for covering the well only and filling the basin and the board signified its desire to have the work completed by the first of June, if possible. Some three or four ready prepared designs were handed me, and each of the three members of the board privately gave me the outline of an idea which he would like to have developed. As requested, I prepared designs until some thirteen in all were considered. It is clear that the board had given the matter considerable thought, and it was therefore with some hesitation that I advised the design used and which was quite different from those previously considered.

The lowest price named in connection with the four plans first referred to called for an expenditure of $4,500.00 for covering the well alone, exclusive of walls, filling up the basin or other work, all of which items were to be done by the city.



Section A-B-C-D-E.

BASIN AND WELL--WALTHAM WATER WORKS.

We soon developed the probability that it would cost more to fill the basin with earth than to roof it over, to say nothing of the loss of storage which such filling would involve.

My estimate of cost of the plan carried out was $5,854, aside from earthwork or stone walls.

Omitting these items the work has cost $5,187.50.

Everything included up to date the cost has been $5,846.50.

The stone and earthwork were omitted from the estimate because it was not known how much of the stone retaining wall around the old basin would prove to be in such condition that it could be made use of. When we came to do the work we substantially rebuilt the whole. There is perhaps $300 worth of odds and ends of cleaning up and loam spreading yet to be done, and there is in contemplation some landscape gardening; but which is entirely distinct from any connection with the work here described.

All materials save the Guastavino stuff, to be spoken of later, were purchased and all work carried out under the direction of the Superintendent of Water Works, Geo. E. Winslow, and I feel that great credit is due him for his management.

The covering will, I think, be readily understood from the blue prints of the design and more fully illustrated by Mr. Winslow's progress photographs, taken by him from time to time as the work progressed. [Blue prints and photographs were distributed.]

The basin is covered by ten inches of loam, overlying coarse gravel from two to twenty-six inches in depth (according to location) filled upon covering arches of 4″ brickwork of 23″ rise and 11′ 6″ span, sprung between lintel arches of brickwork 17″ wide and 8″ deep, with 21″ rise and 10′ 7″ span, carried by 17″×17″ brick piers which foot on granite levelers 15″×30″×30″.

The well in the centre of the basin is covered with a material which has been somewhat extensively used for flooring in fire proof buildings; but, it is believed, never before made use of in this country for out of doors construction; although it would seem to be especially well adapted to such purposes as this, being nothing more than a 1″×6″×12″ fire clay, corrugated tile, laid in Portland cement. It is a patented article controlled by the "Guastavino Fire Proof Construction Co.," of New York and Boston, which concern put in this portion of our work.

The only material in any portion of our cover, other than stone, cement or baked clay, is a 4″×6½″ wrought iron, forty-five pounds to the yard, tie ring, entirely bedded in and covered with cement and set to receive the tile of this well cover where it foots upon the well wall.

The economy for us in the employment of this Guastavino construction was that by its use we were able to avoid expensive centering.

Owing to the nature of materials of which our cover is built, we believe that there will be scarcely any expense for annual repairs and no chance for contamination of the water or foothold for growths which shall befoul it.

Some of our methods of handling materials of construction, etc., might perhaps have an interest; but I will not trespass further on your time except to answer any questions you may wish to ask on points not made clear.

DISCUSSION.

MR. BRACKETT. I would like to ask Mr. Johnson if he can give us the cost of covering the well, separated from the cost of the entire work?

MR. JOHNSON. That was done by contract; it was the only work done by contract. We raised the walls of the well proper up to four inches below the spring line of the roofing. The contract price for the Guastavino roofing, from this point up, including the tiling, iron work and everything, was $1,916.42.

MR. FULLER. We have lately built a covered reservoir at Methuen, and it may be of interest, perhaps, if I give a few items of detail with regard to it. Instead of being a square reservoir like Mr. Forbes's, it is a circular one, very similar to the one which I described last year, which was built at Franklin. This is simply that reservoir with another ring of covering arches put on, of a larger diameter. This reservoir has a diameter of about ninety feet and holds about 1,000,000 gallons. All the excavation was done by day labor. The masonry wall was let out by contract at a $1.50 per perch for the laying. The stone was all taken from a neighboring locality, and paid for at the rate of $1.25 a perch.

The cost of this reservoir will certainly be less than $16,000; we cannot tell exactly yet because all the bills are not in and the work is not entirely finished. There was somewhere about 6,000 yards of excavation and about 1,200 yards of rubble masonry at $1 50 per yard. About 175,000 of bricks which cost on the ground $8.30 and the laying was $6.25. The cement cost about $2,400; the sand delivered on the ground, about $500; the crushed stone for the concrete in the bottom about $128; a road leading up to the reservoir about $112; the lumber for centering about $400; and the carpentry work in putting up this centering about $100. The method adopted for putting on the roof was perhaps a little different from the ordinary method. The centering was all put up before any of the brick covering was laid. The roof is eight inches in thickness, and the whole brick roof was put on in about six days. The whole reservoir was built inside of ninety working days. It cost about $16 to every 1,000 gallons of capacity.

The inlet and outlet pipe is fourteen inches, and comes in through the bottom, an extra thickness of masonry being provided at that point. The overflow pipe is a T put into the horizontal pipe and extending to the top. I expect we shall have an indicator to show the height of the water, so that there will be but little danger of overflowing.

MR. NOYES. I understand the Brookline reservoir has been emptied after having been in service for some months. Do I understand from your description, Mr. Forbes, that the piers in the reservoir were brick, that is a brick surface?

MR. FORBES. They were.

MR. NOYES. How did you find the surface of those brick piers as compared with the concrete surface, if there was any difference? Was there any growth at all on them or indication of anything different from the concrete surface?

MR. FORBES. I didn't see any difference at all.

Mr. Noyes. I might say that it has been something of a question, and one of a good deal of interest to me, whether there would not be a growth of some sort on the brickwork in a covered reservoir which would not be on the concrete. We haven't had occasion or opportunity to examine the inside of the Newton reservoir since it was built, so I cannot say what condition the inside is in ; but we have no reason to believe but what it is as good as when built.

This whole subject has been one of a good deal of interest to me from an engineering point of view, and we have before us to-day extreme types of covered reservoirs. We have the reservoir which has been described by Mr. Forbes, with piers twenty-four inches square and some nineteen feet high ; then the Newton reservoir, which has been referred to, where the piers are twenty inches square and some fifteen feet high ; and in their details they are very similar to each other, it may be the arches have a slightly larger rise in one case than the other. But we have the extreme case before us as presented by Mr. Fuller in the covered reservoir at Methuen, which is somewhat similar in design to the Franklin reservoir, as I remember it, and the piers nineteen feet high and twelve inches square. And we have the case brought before us to-day by Mr. Johnson, which is exceedingly interesting, of arches of four inches springing from piers seventeen inches square.

The point of extreme interest in Mr. Johnson's work is the use of the tile arch, the extreme thinness of the arch, which is some forty feet in diameter, the fact that the arch covering the portion of the filter basin outside of the wall is four inches thick, with no solid spandrel filling, and without apparently earth filling ; and, apparently, twelve inches of earth over the top of the four inch arch. On first looking at the plan it struck me as an extreme case of light work, and I should like very much if Mr. Johnson could give us a little more information as to the practical results, that is so far as stability goes as indicated up to the present time. It becomes us as engineers to design our work with sufficient stability to do the work required, and at the same time to save as far as possible the expense which may be wasted in making work of unnecessary dimensions. And if the designs as carried out by Mr. Johnson and Mr. Fuller show sufficient stability in a length of time, it shows us what we can do with good work, and how much we really can save for our clients. Of course it is an exceedingly delicate matter for an engineer to adopt these extreme conditions if he hasn't precedents of successful work to draw his conclusions from.

Mr. Johnson. If Mr. Forbes will kindly answer one question before I answer Mr. Noyes, I think it will bring out very clearly the underlying distinction between the two pieces of work. I would like to ask Mr. Forbes about how much cement he mixed at a time, and how many persons there were using from a mixture at the same time ?

Mr. Forbes. We mixed half a barrel at a time.

Mr. Johnson. Wet the half barrel at once ?

Mr. Forbes. Yes. We had four masons working in one gang, and it would last generally from fifteen to twenty minutes.

Mr. Johnson. What were the proportions ?

MR. FORBES. Two of sand to one of American cement, in laying the foundation walls.

MR. JOHNSON. That brings out the point I wish to emphasize, not as justifying or otherwise any work we have done, but as bringing out the underlying ideas in the two methods of construction, and the distinct intentions in making the work. I have no question as to the stability of any part of the work, not excepting the four inch covering arches, and there I deliberately omitted any filling in the spandrels between the arches, that is any filling by cement or concrete, though it is filled with gravel. And I did it with a view to economy, and also in consideration of the conditions under which we worked. Our work is a filter basin not a storage reservoir. We have a bank of material against it which has been in place a long while. The heaviest weight which we think can ever come upon it will be a crowd which may gather to view a boat race on the river. Now, in designing the work it presented itself to me whether to put the additional expense which would be required into concrete backing in the spandrels, in the valleys, or omit it, and I took the alternative of omitting it for the sake of saving expense, believing that we had ample strength. But I paid particular attention to mixing the cement, to the cement and the way it was treated. While the work was in progress I personally watched the mortar beds more than anything else. I insisted on careful selection of the sand and on all materials being mixed very dry, indeed during a portion of the work we heated our sand for the purpose of getting it dry. Then the cement was wet pailful by pailful, although there were from six masons upwards at work all the time, and I suppose the cement wasn't wet two minutes before it was in place in the work. The brick before being used were soaked in water and then allowed to drain for something like twenty minutes; and the amount of water was carefully gauged in mixing the cement. I think the brick certainly did not rob the cement of any water, and that the initial set of the cement would be a permanent set.

Something like three weeks after the work was completed, we tested it by having four men haul a 425-pound stone roller, with a tread of something like 20 inches over the well, and by examining the amount of bearing I estimated that that test was equivalent to a dead weight of about 1,700 pounds per square foot, under the conditions under which we applied it. By accident the roller at one place dropped about five or six inches on to the covering of the well without any disasterous result. Of course that applied a very much more severe test at that particular spot, and it certainly was not any stronger place than anywhere else. I felt therefore quite well satisfied with the work so far as we could test it then.

MR. NOYES. Was this work laid in American or Portland cement?

MR. JOHNSON. American Rosendale cement was used.

MR. NOYES. Altogether?

MR. JOHNSON. Altogether, excepting in the work of the Guastavino Construction Company. They used Portland cement without the special pains we took in the handling of the American cement. But I really believe we got superior results with our American cement to what they got with the

Portland cement which they used in the work. Their work is amply strong, I do not cast any aspersion on that, but our American Rosendale cement really gives us a stronger cement than they got with the Portland, and the reason is, I believe, the difference in the way in which it was used.

MR. NOYES. What brands of cement did you use?

MR. JOHNSON. We used Connolly & Schaefer and Hoffman; the greater portion of the cement used was the Hoffman cement.

MR NOYES. Did you use any different method in mixing your Portland and American cements, Mr. Forbes?

MR. FORBES. I did not. The Portland cement was used on the brickwork only, and mixed in much smaller quantities.

MR. NOYES. Was American cement used on the brickwork in the arches?

MR. FORBES. No; all the brickwork in the arches were laid with Portland cement mixed in very small quantities, a pailful or so at a time.

MR. NOYES. That is, you would use greater care in mixing the Portland than the American?

MR. FORBES. We did, but at this time of the year it had got rather cold; and of course cement mixed in the winter time, with the thermometer about forty, will set very much slower than in the summer time when the thermometer is seventy or eighty.

MR. NOYES. I should like to ask Mr. Fuller whether he used American or Portland cement?

MR FULLER. We used, I think, a mixture in the piers of American cement and Portland cement, but in the covering arches and in the stone work, and in the rubble masonry wall, the cement was entirely American cement. At Franklin we used Portland cement entirely in the piers.

MR. NOYES. Was that on account of the design?

MR. FULLER. No, we thought it would set quicker and that the piers would be less liable to swaying and distorting by getting out of plumb. By staying them we had very little trouble, and I don't think after the lintel arches were on there was ever any movement of the piers at all.

MR. FITZGERALD. I think there is one point in connection with these covered reservoirs that has not been fully dwelt upon, and that is the head of the water on the outside. When the reservoir is full and kept full for some time, the head of water outside must be about the same as on the interior, and as there are violent and sudden fluctuations in the level, when the water is drawn down, I would like to ask Mr. Forbes and Mr. Fuller if they have made any investigations on the question of the strength of the bottom to resist the upward pressure, if that has entered into their calculations? I notice that in both of these reservoirs there is no invert, and a very thin floor composed of clay and a thin lining of concrete.

MR. FORBES. I remarked in my paper that when the bottom of the reservoir was built on material where the water was liable to get under the concrete, you might make the bottom like the top; that is you could spring arches from the piers, thus forming a bottom that could not be forced up under any circumstances, without forcing the whole roof up. Our reservoir

we built in an excavation in one of these clay hills like Parker Hill. When we first filled the reservoir we let it stand nearly full for, I think, ten days, and then we drew it off, and it was empty for a week or ten days, and I didn't see any indication of the water forcing the concrete up on the bottom. In fact the whole reservoir was practically tight; there was no water coming in anywhere. This summer, after the reservoir had been in use several months, we drew it off again, and we examined the bottom and sides carefully, and there was no indication of water entering through the walls or forcing itself up through the bottom. That is one reason why I say the walls of a covered reservoir should be very thick and very carefully made, because if there are spaces in the wall, when the water suddenly falls the flow through this wall might wash some of the clay, perhaps, back of it, and if it once began to wash the hole would gradually get larger and larger, and it would be only a question of time when the whole would tumble down. And having this in mind was one reason why I adopted a very heavy construction of the side walls, so as to guard against the water which may rise on the outside of the walls, perhaps, nearly as high as the overflow line, and then, when the water in the reservoir is suddenly drawn down and it is nearly empty, as our reservoir fluctuates from five to thirteen and fifteen feet every twenty-four hours, if there were pits in the bottom of the wall, or if there were pits back of the wall, or if there was any chance for the water back of the wall or in the wall or behind the wall to get underneath the concrete in the bottom and pass through, then it would only be a question of time when it tumbled down. That is one reason why we poured down barrel after barrel of cement and formed a grout around the stones, so as to be sure there couldn't be any holes or any chance for this water to run back and forth through the wall. I think that ought to be guarded against, or sooner or later it may all come down.

Mr. Fuller. I would say with regard to the Franklin and Methuen reservoirs, they were both built in material which was very hard, compact and homeogeneous, and I think it would be very unlikely the material would hold much water anyway. The filling behind the walls in both cases was thoroughly rammed and a great deal of time and labor was spent in both cases in making the backing thoroughly hard and compact, I don't see how it can pass much water. The Franklin reservoir was drawn off after it had been in use about a year and a half and carefully examined, and so far as I know there was no indication whatever of any rise on the bottom. The Metheun reservoir has not yet been filled, but I apprehend no trouble on that ground, and I see no reason why there should be.

Mr. Coffin. We have had an experience with the reservoir at Cohasset It was covered with cement concrete six inches thick, with one inch of plaster on top; this covered the bottom, went up the sides and into the bank under the core wall. The water was drawn down suddenly one day, and the superintendent saw the bottom beginning to rise. He went into the gate house and got an ax and went down and cut a hole in it, and the water gushed up and the bottom went down. The reservoir was built in material which

seemed to be almost absolutely impervious to water, but in drawing it down so suddenly I suppose there was a pressure upwards on the large surface on the bottom. I presume it is different in these covered reservoirs, where the bottom is divided up into small squares by the piers; I don't know just the construction of those piers but they probably have some effect at least in shortening the span and holding the bottom down. I mention this as one instance where the bottom of the reservoir came up from the pressure of the water.

Mr. FitzGerald. There is one other matter I want to refer to. I am not quite sure as I heard distinctly, but I thought I heard one member say his experience in some of his work had led him to believe that the American cement had given better results even than the Portland, and he mentioned certain brands. As this is so entirely contrary to all engineering experience, I hope further details will be given to us, so we may become thoroughly acquainted with the foundation for this experience as it certainly ought to be of a great deal of value if founded on absolute experiment and fact.

This large well at Waltham is an extremely interesting one. I have for some years taken an interest in these large wells, and from time to time have seen them in process of construction; and particularly in the west they use a great many of them, both for public water supply and for furnishing railways with water to fill their locomotives. Nothing has been said here today about the method of sinking these wells. I have seen wells from twenty to forty feet in diameter, sunk from thirty to forty feet in depth, and varying in cost from $20,000 to $2,000, depending upon the method of putting them down, and the amount of care and thought expended in that direction. One of the largest wells I know of, and one of the most remarkable, and one of the first ever built in this country, is in Prospect Park, Brooklyn. That is a brick well fifty feet in diameter, and sunk to a depth of sixty feet. It was built on a curb and sunk that depth by excavating very carefully in the interior; and that is the method generally employed, where economical construction is provided for, I think. Of course there are places where, perhaps, it is not possible to do it. I thought it might be of interest to call the attention of members to this matter of sinking If any of you are going to put down large wells, that is one of the most important things to study in the beginning.

Mr. Johnson. I think Mr. FitzGerald has reference to me in speaking of Portland and American cement. I perhaps did not make myself clear. I did not wish to be understood as making any statement that American cement, used under the same conditions, is superior to Portland cement. What I did intend to say was this, that the Company using the Portland cement in this case, mixed their cement and wet it some little time before it went into their work; and while nominally mixed two to one, I think really it was a good deal nearer three and a half to one. They did not measure the materials as they went in, as we did. Our cement was used with brick which were very damp, and yet not running in water, and before the cement had been wet more than five minutes at the outside, it was in place on the brickwork. The

Portland cement had been wet for some little time in many instances before it was used in the work, and their tiles were used entirely dry. I permitted the work to go in in that way because of the guarantee they gave us that the work should be submitted to a test which we approved, which it amply stood, and further, because I believe that ample strength was had by that use of the cement. Perhaps that answers Mr. FitzGerald's question.

Mr. Walker. We do all our business at Manchester open and above board. The reservoirs are all open and the saloons are all open. (Laughter.) We are about to build a reservoir in a solid ledge, and I want to ask if any engineer who can tell me how to make it tight. I understand there is some difficulty in getting a tight reservoir in rock where there are seams

Mr. Tidd. Mr. Walker seems very anxious to know how to fill up the cracks in a ledge, and to be afraid that his reservoir won't be tight. I should say with the saloons all open it might get tight. (Laughter.) A reservoir in solid ledge is rather expensive, perhaps, but my idea of an ideal reservoir is one which would be solid masonry, and if the masonry is properly put in, it can be made tight. I suppose a reservoir in any ledge, and I never saw a ledge that wasn't seamy, can be made tight with proper lining. The lining probably would have to be cement or clay, and cement would be better. A friend of ours built one in Woburn in a ledge, and he had some difficulty in making it tight, but he afterwards accomplished it by lining it with clay. When they first commenced to pump into it, they got it about half full and they couldn't get the water any higher ; so they drew it down and lined it inside with clay and it has been all right ever since, about twenty years. I don't think Mr. Walker will have any difficulty if he goes to work in the proper manner.

Mr. Walker. How thick should the lining be on the bottom ?

Mr. Tidd. They didn't put any on the bottom, but on the sides they put six inches of clay.